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(71) Applicant: IEP PHARMACEUTICAL DEVICES INC.  
[US/US]; 6320 Angus Drive, Raleigh, NC 27617 (US).

(72) Inventors: SEXTON, Frederick; 161 Kemp Avenue,  
Fair Haven, NJ 07704 (US). ADJEI, Akwete, L.; 15

Tillman Court, Bridgewater, NJ 08807 (US). GENOVA, Perry, Arthur; Post Office Box 16036, Chapel Hill, NC 27516 (US). MELKER, Richard, Joel; 6101 NW 19 Place, Gainesville, FL 32605 (US). VAN OOSTROM, Johannes, Hugo; 4420 NW 31st Terrace, Gainesville, FL 32605 (US). SCHMALFUSS, Ilona, Maria; 2120 NW 20th Street, Gainesville, FL 32605 (US). MANCUSO, Anthony, A.; 10122 SW 67th Drive, Gainesville, FL 32608 (US).

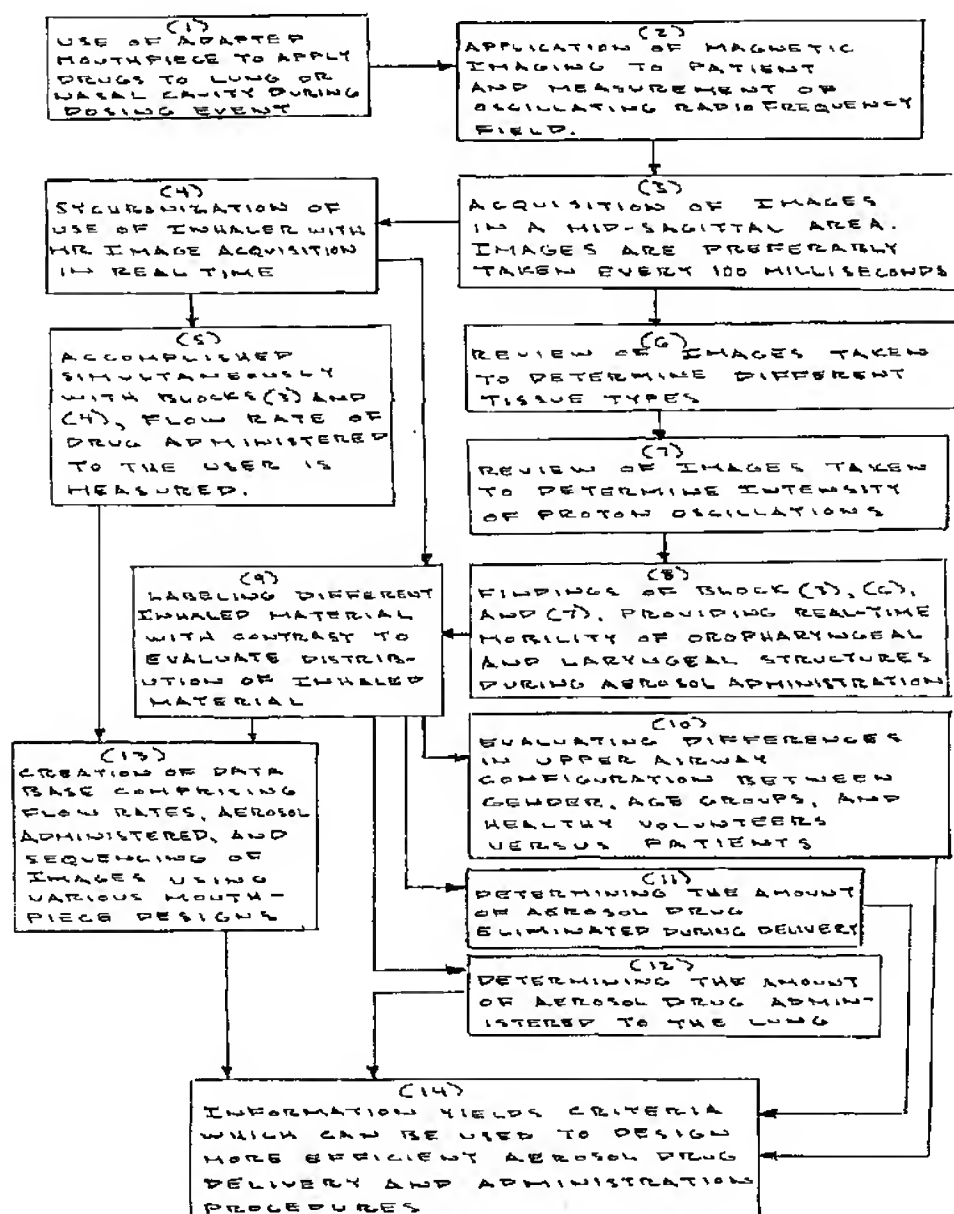
(74) Agents: SANTUCCI, Ronald, R. et al.; Pitney, Hardin, Kipp & Szuch, LLP, 20th Floor, 711 Third Avenue, New York, NY 10017 (US).

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(54) Title: METHOD FOR IMPROVING LUNG DELIVERY OF PHARMACEUTICAL AEROSOLS



(57) Abstract: Disclosure is made of a method employing real-time imaging techniques such as Magnetic Resonance Imaging in order to investigate the effect of air way structures or administration and respiratory drugs when administered by oral inhalation. The information obtained from the practice of this method yields the criteria that can be used, among other things, to design more efficient aerosol drug delivery systems which optimize the amount of medicine delivered to the lung.

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METHOD FOR IMPROVING LUNG DELIVERY OF  
PHARMACEUTICAL AEROSOLS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

5           The present invention relates to a method of monitoring the role of upper oropharyngeal and laryngeal geometry for the retention and elimination of respiratory drugs when administered by oral inhalation. The method is based primarily  
10 upon acquiring real-time MRI images of human subjects while using aerosol inhalation devices. From these image sets and the data accumulated, one may determine design criteria of the delivery device to optimize the delivery of pharmaceutical  
15 aerosol to targeted pulmonary sites. Condition variables include particle size, device attributes such as mouthpiece shape and resistance to flow, aerosol exit velocity, and inhalation flow rate.

20 DESCRIPTION OF THE PRIOR ART

          Magnetic resonance imaging techniques have become widely accepted in medical practice as a means of investigating structural and anatomical differences in body tissues and organs: Justin P.  
25 Smith, "Magnetic Resonance Imaging Using Pattern Recognition" U.S. Patent No. 5,311,131; Hiftje, et al. "Method And Device For Spectral Reconstruction" U.S. Patent No. 4,642,778; and Shendy et al.  
          "Method For Obtaining T1-Weighted and T2-Weighted  
30 MNR Images For A Plurality Of Selected Planes In

The Course Of A Single Scan" U.S. Patent No. 4,734,646. In a typical medical application, a patient is placed within the bore of a large, circular magnet. The magnet creates a static magnetic field that extends along the long (head-to-toe) axis of the patient's body. An antenna (e.g., a coil of wire) is also positioned within the bore of the large magnet, and is used to create an oscillating radio frequency field that selectively excites hydrogen atoms (protons) in the patient's body into oscillation. The oscillating field is then turned off, and the antenna is used as a receiving element, to detect the proton oscillations as a function of position within the body. Typically, the intensity of the oscillations is measured throughout a two-dimensional plane. When the intensities are displayed as a function of position in this plane, the result is an image that often bears a striking resemblance to the actual anatomic features in that plane. The intensity of proton oscillations detected at a given point in the patient's body is proportional to the proton density at that point. Because different types of tissues have different proton densities, different tissue types usually have different image intensities, and therefore appear as distinct structures in the MR image. However, the signal intensity also depends on physical and chemical properties of the tissues being imaged. In a simplified model of MRI, the detected signal intensity, as a function of position coordinates  $x$  and  $y$  in the plane being imaged, is proportional to

$$(1 - e^{-TR/T_1}) e^{-TE/T_2}$$